

# DOCUMENTED BRIEFING

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## *The Use of Microworld Simulations to Train Theater-Level CSS Staffs*

*Training Development  
Considerations*

*Emile Ettedgui, David Oaks,  
John R. Bondanella*

*Arroyo Center*

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*Training Development  
Considerations*

*Emile Ettedgui, David Oaks,  
John R. Bondanella*

*Prepared for the  
United States Army*

**Arroyo Center**

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## PREFACE

The changing nature of the U.S. Army's operational environment and its growing dependence on force deployment place a high priority on the early deployment of combat service support (CSS) units, which are essential for the support of U.S. forces in a theater contingency operation. The Army is in essence also reengineering itself under the auspices of Force XXI. These challenges and changes to CSS management will occur in an increasingly information-rich and distributed environment. The training methodology and training support tools for the higher-level command and control headquarters of these CSS units (many of which are in the Reserve Components) have been updated slowly, if at all, to meet the demands of the changing environment. Earlier aspects of this research reported on the opportunity to reexamine training for support staffs above the division level and determine how the Army might change its training to best prepare for new styles of CSS management.<sup>1</sup> This report discusses a microworld<sup>2</sup> simulation modeling approach that can help to facilitate changes in structure and content for training CSS staffs operating as staffs. This report illustrates how microworld models can be used to train CSS processes.

The Deputy to the Commanding General of the U.S. Army Combined Arms Support Command asked the RAND Arroyo Center to propose new methods for training high-level CSS staffs. The work presented in this document should be of interest primarily to those engaged in the development of this training doctrine and secondarily to the members themselves of these CSS staffs. This research was conducted in the Manpower and Training Program of RAND Arroyo Center, a federally funded research and development center sponsored by the United States Army.

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<sup>1</sup>See John R. Bondanella et al., *Microworld Simulations for Command and Control Training of Theater Logistics and Support Staffs: A Curriculum Strategy*, Santa Monica, CA: RAND, MR-929-A, 1999.

<sup>2</sup>Microworld simulation is a term we use to define a class of software models used in teaching end-to-end systems thinking. These models are built from commercial software packages using libraries of preconfigured process steps (for example: decision, measurement, transactions). They provide a practical framework to combine a series of processes into an end-to-end system. The term is generic and is in no way connected with a product or service. This term was used earlier to describe a similar approach by Seymour Papert in *Mindstorms, Children, Computers, and Powerful Ideas*, New York: Basic Books, 1980.

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## SUMMARY

This documented briefing provides some guidelines for the development of a promising new method for teaching the complex skills required of high-level combat service support (CSS) staff members.

The goal of training for theater-level CSS staffs is to master complex skills. These individuals will need to find important trends in streams of data, determine their likely impacts on the ongoing operation, and finally influence CSS operations to achieve the desired support. Today's training methods and tools—narrow in scope, cumbersome, and resource-intensive—train these skills poorly. The Army's Combined Arms Support Command (CASCOM) asked the Arroyo Center to develop a better way to train these staffs.

At the heart of the new methodology for CSS staff training is the development of a skills matrix, supported by microworld training tools. The skills matrix departs from current checklists of staff tasks found in mission training plans (MTPs) by laying out skills at a greater level of detail and by providing flexibility in the groupings of skills used to train particular staff sections or members. Microworld models, or "management flight simulators," are an excellent training tool. Created using commercial-off-the-shelf (COTS) software, these models can be quickly developed and modified to meet specific training needs, can be disseminated widely for individual training or used in group training sessions, and can be acquired at a cost much lower than those of traditional training simulations (such as CSSTSS or CBS). Two prototype models—a hypothetical theater distribution system and the POL distribution network in the early phases of Operation Joint Endeavor (Bosnia)—demonstrate the promise of the microworld as a training tool.

Several lessons for CASCOM, as the training developer of the microworld models, became apparent in this research project. The first is to purchase a commercial software product to avoid the need to write both code and CSS models. Next, this commercial software should be equally able to read input data from existing sources (such as spreadsheets) and to generate mathematical functions and statistical probability distribution functions from a built-in menu. Similarly, it should have an existing library of objects and functions and be able to support the idea of different

hierarchies—student, trainer, or training developer. Finally, the software should have a good graphical user interface.

The road ahead for CASCOT to implement the microworlds training methodology is straightforward. At the core is the development of a skills matrix for CSS C2 staff training. With the help of an existing simulation software package, CASCOT training developers can practice running prototype models and then continue to experiment with additional prototypes, ultimately developing models for use by CSS C2 staffs in their training and exercise programs.



## ACKNOWLEDGMENTS

The authors appreciate those who have helped through the varying stages of this project. Foremost is George Park, our first prototype microworld model developer, who has since departed RAND. Matthew Lewis and Dina Levy have helped to refine our microworld models for better representation as cognitive learning tools. West Point Cadet Andrew Nelson was assigned to RAND for his active duty training during June 1998; during his four-week assignment, he gathered some of the existing reports and data on Operation Joint Endeavor petroleum operations, which we used to construct our prototype real-world case model. We benefited from the critiques of our initial ideas by RAND colleagues who attended in-house seminars. Key supporters throughout this research were J. Michael Polich, our program director, and John Winkler, associate program director. Jerry Sollinger helped articulate our concepts more clearly in this document. Nikki Shacklett helped with editorial aspects.

Thomas Edwards, Deputy to the Commander, U.S. Army Combined Arms Support Command (CASCOM), and Bruce Schoch, Applied Technology Division, Training Directorate, CASCOM, have provided their insights on the direction and applicability of these tools in staff training.

We sincerely appreciate the suggestions made by the ultimate training audience—the soldiers who participated in our pilot studies from the U.S. Army 310th Theater Support Command (Provisional), 55th Materiel Management Center, and 4th Movements Control Center, Fort Belvoir, Virginia, and the U.S. Army 311th Corps Support Command, Los Angeles, California. In particular, Captain Eric Brown suggested that we use the Operation Joint Endeavor fuels distribution process in developing a prototype model based on real-world information and processes; Captain Brown is a reservist who was activated for deployment to Operation Joint Endeavor with elements of the 55th Materiel Management Center.

The authors are solely responsible for any errors or omissions.

## ABBREVIATIONS

AC	Active Component
AT	Annual Training
ATP	Ammunition Transfer Point
C2	Command and Control
CASCOM	(U.S. Army) Combined Arms Support Command
CBS	Corps Battle Simulation
CONUS	Continental United States
COTS	Commercial, Off-the-Shelf
CSS	Combat Service Support
CSSTSS	Combat Service Support Training Simulation System
DISCOM	Division Support Command
GUI	Graphical User Interface
IDT	Inactive Duty for Training
MMC	Materiel Management Center
MTP	Mission Training Plan
OJE	Operation Joint Endeavor
POL	Petroleum, Oil, and Lubricants
SSA	Supply Support Activity
TAACOM	Theater Army Air Command

# **The Use of Microworld Simulations to Train Theater-Level CSS Staffs: Training Development Considerations**

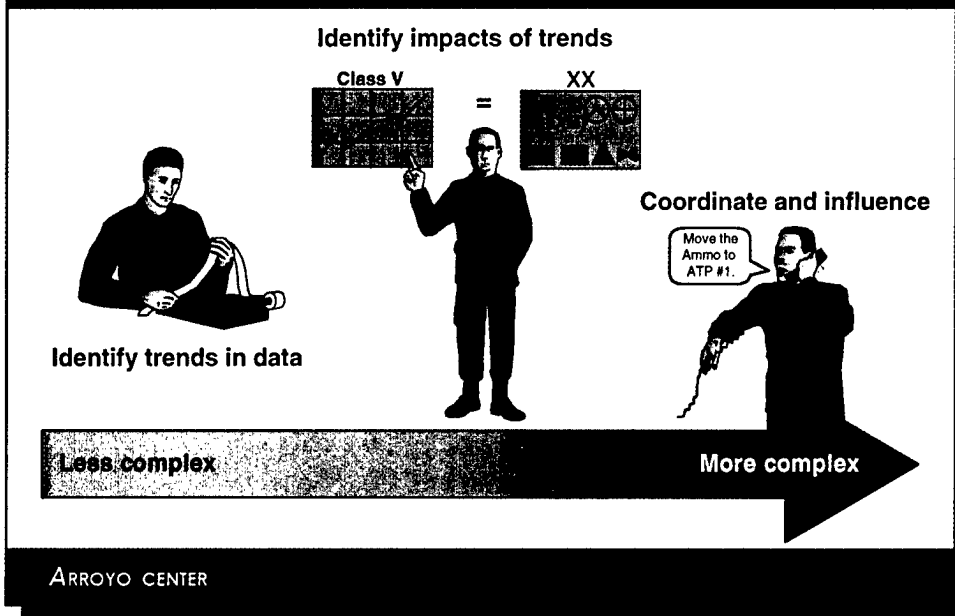
**Emile Ettedgui, David Oaks,  
John Bondanella**

**September 1998**

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This documented briefing discusses some considerations for the development of a promising new method to teach the complex skills required for high-level CSS staff members. It provides an overview of personal computer simulations that we developed as prototypes during our research on combat service support command and control (CSS C2) staff training. It discusses how the training development community ought to view this class of simulation models, and it suggests some considerations for training developers as they decide how such commercial-off-the-shelf simulation model authoring tools might be acquired and developed by the Army or its contractors. The background and broader research topics are provided in more detail in another project publication [1].

## The Goal of Theater-Level CSS Staff Training: Ability to Perform Complex Skills



The goal of training for theater-level CSS staffs is to master complex skills. At this level, staff officers will not be able to effectively or efficiently observe physically what is going on around them in the theater. Thus they will depend upon flows of information coming to them from the many CSS activities—strategic and in-theater transportation, port operations, supply bases, etc. They will need to analyze these data, looking for important trends. Next, at a higher level of difficulty, they will need to determine how these trends are likely to affect the ongoing operation. Finally, and most difficult, they will need to influence CSS operations to achieve the desired support. Today's training methods and tools poorly train these skills for higher-level theater CSS staffs.

## **Theater-Level CSS Staff Training Today: Poorly Served by Existing Approach**

- **Primarily focused on exercises that:**
  - have short time frames
  - occur infrequently
  - don't exercise the breadth of CSS missions
    - lots of preparation
    - not flexible
    - mostly concerned with the fight, not support
- **Difficult to use for reserve component IDT weekend training**

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Current logistics exercises are too narrow in scope, focusing on events or decisions after the theater has been established and is mature. Therefore, CSS staff are not given the opportunity to practice the management of a dynamic, growing support system.

Second, these exercises are not integrated in time and content; training is not conducted over the year or from year to year. Most training events occur over just a few days, and they look at support in only one aspect of an operation—for example, support of the maneuver force within a mature theater CSS system or the reception of a reinforcing force.

Current simulations focus on maneuver forces, not theater CSS staffs. Simulations such as CSSTSS or CBS are not intensive or realistic for higher-level theater CSS staffs. It is also troubling that the use of these simulation tools requires an investment of time just to teach soldiers how to use them (i.e., not how to be a CSS staff member).

CASCOM has considered RAND's approach as a first step toward improving the methods used to train higher-level CSS staffs for Force XXI.

## **A New Methodology Is Needed for Training CSS Staffs**

- **CASCOM has a promising alternative**
  - Development of skills matrix
  - Microworld models support this approach
- **RAND Arroyo Center has done a field test**
  - TAACOM staff training during IDTs and an AT
  - Measurable improvement in skills and learning
- **This approach should be institutionalized**
  - Redesign CSS staff mission training plans (MTPs)
  - Further develop microworld models
  - Distribute as a coherent training package

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At the heart of the new methodology for CSS staff training is the development of a skills matrix, supported by microworld training tools.

The Arroyo Center has conducted small pilot studies with staff members from CSS headquarters organizations to demonstrate how a process approach might be implemented in a training event. The pilot studies provided sufficient information and confidence in the training approach to enable the Arroyo Center to carry out a larger-scale demonstration, allowing us to gauge our materials, questionnaires, and training schedule. The larger-scale demonstration was designed to collect statistical information about the curriculum.

The demonstrated success of this training strongly suggests that the Army should institutionalize this approach to training CSS staffs. The major parts of this implementation include the revision of existing CSS staff mission training plans to reflect the skills matrix and the incorporation of microworld models in a coherent staff training curriculum.

## **Purpose**

- **Describe the CSS training methodology proposed to CASCOT**
- **Illustrate the use of microworld models to implement this methodology**
- **Provide lessons learned from this project**

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In the remainder of this documented briefing, we give a fuller description of the skills matrix approach to training, followed by an exposition of two prototype microworld models developed to train sets of these skills. Finally, we present some lessons from this research and suggestions for further implementation of this training methodology.

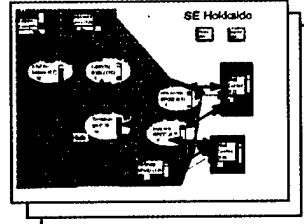
## New Training Methodology Proposed to CASCOM

- Based upon management skills matrix
  - Deeper levels of detail and specificity of tasks beyond that found in existing mission training plans (MTPs)
  - Subsets of skills are chosen for focused staff training
- Skill sets trained using microworld simulation tools

Management skills matrix

Basic System Knowledge	Measuring, Diagnosing, Managing Complex Systems
<b>Identify and describe the system</b> Identify the system's purpose and function. Identify the system's components and their interrelationships. Identify the system's inputs and outputs. Identify the system's constraints and limitations. Identify the system's history and evolution.	<b>Identify and describe the system</b> Identify the system's purpose and function. Identify the system's components and their interrelationships. Identify the system's inputs and outputs. Identify the system's constraints and limitations. Identify the system's history and evolution.

Microworld simulations



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At the center of this new training methodology is the skills matrix (a suggested prototype is shown in more detail on the next page) that represents a departure from the current checklists of tasks found, for example, in the CSS staff mission training plans (MTPs). There is currently no MTP for a theater army area command, the highest-level current logistics organization in a theater. TAACOM is the largest and the dominant of the CSS organizations being merged into the TSC. The theater support command training literature is still in development, and thus there is an excellent opportunity to adopt this new approach. The combination of focused microworld models with the matrix as a new approach to MTP design provides the flexibility to train individuals or smaller groups in a staff on a particular subset of skills to better master their particular staff responsibilities.



## Sample Skills Matrix for Materiel Distribution Management

Basic System Knowledge		Measuring/Diagnosing, Managing Complex Systems		
<i>Basic/Enabling Knowledge/Skills</i>	<i>System Understanding</i>	<i>Building/Expanding Operations</i>	<i>Executing Normal Operations of Systems</i>	<i>Handling Exceptions/ Crises</i>
Identify main supply routes	Develop/implement transportation networks	Design distribution network	Monitor status of distribution network & manage its flow	Take appropriate actions to work around choke points
Determine stockage levels	Understand alternative modes of distribution	Anticipate logistical requirements	Manage upstream supply/ material flows	Prioritize requirements, reallocate resources to meet objectives
Understand modal resources	Understand HN support, integration	Implement distribution network	Manage & track asset status	Integrate available assets to meet distribution needs
Filter/utilize logistics info	Understand automation information systems	Develop system that continually reviews relevant information	Keep system in equilibrium	Use alternative information gathering techniques
Understand evolving logistics techniques, doctrine, and procedures.	Understand JIT resource mgmt	Incorporate state-of-the-art processes	Monitor relationships with sources of supply	Establish procedures to minimize crisis impact

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MTP lists contain assortments of tasks, from the simple to the complex. However, as the complexity of the task increases, the MTP states generalities, e.g., "coordinate staff actions." The matrix approach advocated in our methodology improves upon the MTP by adding greater depth and detail to the sorts of skills that are required to achieve staff coordination at the senior CSS level. The matrix approach provides a more comprehensive framework for evaluating staff training needs based on their mastery of skills, from a basic system knowledge to the more demanding skills of measuring, diagnosing, and managing complex systems. The training developer could use this matrix to design and build very focused microworld models and rapidly tailor them to a particular staff's training requirements. The remainder of this document discusses the prototype models we developed using the matrix approach.

## **Microworld Training Tools Offer Many Advantages Over Existing Simulations**

- **Available**

- rely on existing COTS automation products
- debugged, technical support available as needed
- not writing code; efforts focus on model relationships

- **Flexible**

- balance the depth and breadth of missions
- can rapidly adapt models to train specific skill sets

- **Fits well with Force XXI strategy of using information technology to enhance force effectiveness**

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Before discussing examples of the prototype microworld models, it is helpful to discuss further the desirable aspects of microworld tools. As mentioned earlier, existing large simulations used in support of CSS staff training suffer from a number of serious drawbacks. They are costly to develop in terms of time, personnel, and money. In addition, they are difficult for the training audience to fully understand, and they tend to have a very narrow operational focus. While simulations will remain a preferred method for supporting CSS staff training, we suggest the use of a new kind of simulation.

Microworlds offer many advantages over today's approach to CSS staff training. Commercial-off-the-shelf (COTS) software allows training developers to focus on the models themselves, not the authoring of underlying code. COTS software is generally free of coding errors (bugs), and the commercial providers offer technical support as needed. The scope of microworld models aids rapid development. The goal is to model a discrete set of policies, processes, and behaviors in support of a theater. Such models are easy for the training audience to understand, since they focus on the specific skills to be trained. The strategy of using technology to enhance force effectiveness fits well with the Army's overall Force XXI strategy.

A number of companies offer authoring tools for microworlds. For simplicity in presentation, this document discusses how we used one of the available authoring tools—Extend, by Imagine That, Inc.—to develop prototype simulations for use in an actual unit's CSS C2 staff training program. However, by this selection, we do not endorse Extend as the tool of choice over any other commercially available product, since we have not conducted a formal assessment of the competing products. We selected Extend based on its graphical user interface, ease of use, low cost (less than \$1,500 for the authoring version), and suite of underlying mathematical probability distribution functions.

The advantage of using standard software such as Extend becomes evident early in the operation and creation of simulations. For the student, the graphical interface is an intuitive, easy-to-grasp representation of the simulated process. The trainer can easily connect elements of the simulation to create different scenarios for additional training. The trainer can also access additional simulation elements in program libraries. These libraries contain standard functions as well as custom capabilities created by the simulation developer. Microworld simulations can be created with different levels of resolution, depending on the lessons that they teach. To reflect this, the developer can choose the appropriate level of aggregation in coordination with the trainer. The focus of a particular training objective may also affect whether the time flow during the simulation proceeds continuously or in discrete steps.

# Training a Set of Management Skills

## Ex: Skill set to train "Distribution System Management"

Measuring, Diagnosing, Managing Complex Systems		
Building/ Expanding Operations	Executing Normal Operations of Systems	Handling Exceptions/ Crises
Plan for/anticipate logistical requirements	Monitor distribution network status & manage its flow	Take appropriate actions to work around choke points
Design distribution network with adequate flow and robustness	Manage upstream supply/material flows	Appropriately prioritize requirements reallocate resources to meet tactical objectives

### Management Skills Matrix

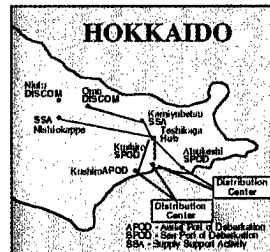
Basic System Knowledge	System Understanding	Building/ Expanding Operations
Identify main supply routes	Understand transportation networks	Develop balanced distribution networks
Determine storage levels	Understand alternative modes of distribution	Run logistics support requirements
Understand modal resources	Understand support integration	Design distribution network with adequate flow and robustness
Filter/Lift SES info	Understand information systems	Develop systems that continually evolve enhance fit
Understand existing SES techniques and procedures	Understand JF resource mgmt	Monitor/maintain relationships with established sources of supply

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In this example of the new training methodology, the first step is the selection of a set of skills from the matrix to train the task of "distribution system management."

## Example Microworld Model to Train Theater Distribution System Management

- Hypothetical scenario
  - Contingency operation on island of Hokkaido
  - Generic supplies (no particular classes represented)
- Realistic transportation assets and capacities
- Theater structure static and doctrinal



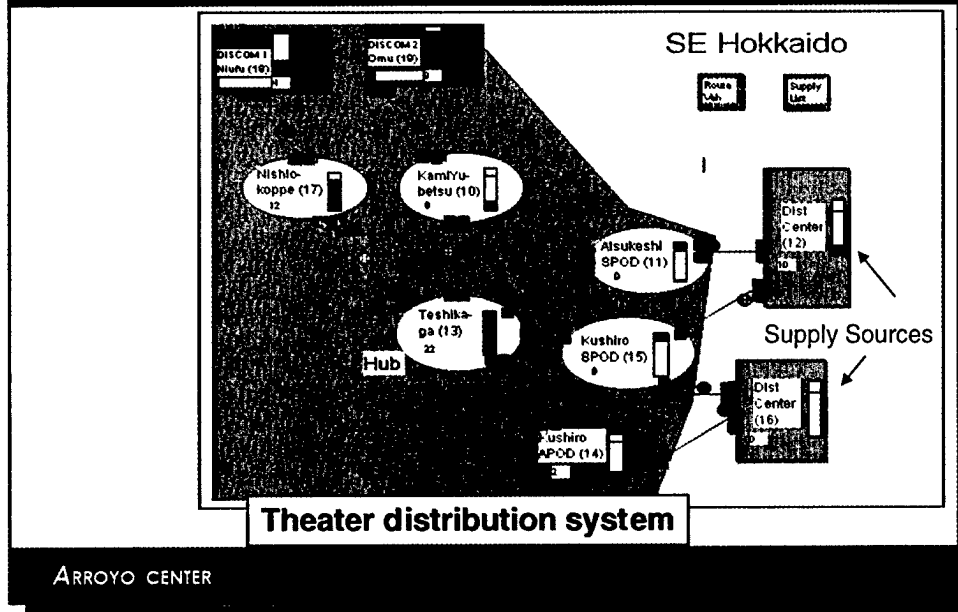
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The Hokkaido prototype model represents the transportation and distribution of generic supplies. It does not attempt to represent every single step in these processes. Rather, it conveys the information necessary to teach important concepts. Although information is aggregated, the model remains faithful to the concepts of the processes it represents.

The stylized scenario represented could be used in a theater-level command post exercise that includes elements located on the Japanese island of Hokkaido. In this microworld game, the theater is "mature" in that the support elements and basic infrastructure of ports and supply points are in place. Also, this theater structure is essentially "static," meaning it is not expected to grow or contract (to serve more or fewer forces) or to need to change to support a different mission.

Two distribution centers, one in CONUS and the other in Japan, supply two seaports, at Atsukeshi and Kushiro, and one airport, also at Kushiro. These ports, in turn, feed supplies to Teshikaga. From here, supplies proceed to two supply support activities at Nishi-Okappe and Kami-Yubetsu, and eventually to DISCOMs at Niifu and Omu. The Hokkaido map shows the relation between the various nodes in the distribution network.

## Microworlds Are Easily Configured Using a Personal Computer



This chart shows the theater distribution system as it appears in the model. The background is a simplified map of the southeast region of Hokkaido. To the right of the island are two distribution centers. One represents CONUS and the other Okinawa. These serve as sources of supplies for the simulation. From the distribution centers, supplies flow either to one of the two seaports or to the airport. The supplies continue to flow, through the hub, on to the forward supply centers and up to the DISCOMs.

Each point in the distribution network displays the name of the node, a node number in parentheses, and information about the level of supplies at that node. The level of supplies is shown by a number that appears in a white box below the name and number of the node. A graphical representation of the level of supplies also exists in the form of a vertical box. As the level of supplies increases, the box changes from white to black, with the height of the black area proportional to set levels for a given node. Above this box is another box that changes color. It is white when the level of supplies falls within a set range. When the level of supplies falls below the safe level or increases past the desirable stocking level, the box turns red.

Before beginning a simulation, the user can set the levels of supplies and the consumption rate at each node. Additional parameters can be set by the user from the notebook; this will be explained later.

Supplies travel between nodes along arcs that correspond to sea, air, or ground transportation routes, as appropriate. The time required for a given transportation resource to travel along an arc depends on the speed of the particular resource in use and on the delay associated with travel along the arc. The distance between any two nodes is not constant, so the time required for a transportation resource to travel between nodes may not be uniform throughout. Similarly, all transportation resources do not travel at the same speed, so different modes of transportation will not require the same amount of time to cover the same distance.

Every transportation resource used in this model is a different color. In this way, the user can easily ascertain whether each resource is operating as expected. In addition, during the simulation, resources appear hatched when traveling empty and solid when traveling full.

## Control of Parameters for the Microworld Is Facilitated by the Use of a "Notebook"

	C141 63	C130 12	ComAlr 12	StWtr 300	AWtr 3X60	Ferry 200	CH47 5X14	Rail 6X60	M639 10X5	HEMAT 10X11	PLS 10X14	M871 10X15	M872 10X22
	1	2	3	4	5	6	7	8	9	10	11	12	13
Station A	16	14	16	12	16	12	17	15	10	13	14	13	11
Pickup A	1	1	1	1	1	1	1	1	1	1	1	1	1
IDO1	0	0	0	0	0	0	0	0	0	0	0	0	0
#DO	0	0	0	0	0	0	0	0	0	0	0	0	0
IDO2	0	0	0	0	0	0	0	0	0	0	0	0	0
#DO	0	0	0	0	0	0	0	0	0	0	0	0	0
Station B	14	13	14	11	15	15	18	13	19	10	13	17	13
Pickup B	0	0	0	0	0	0	0	0	0	0	0	0	0
Speed (1-4)	4	4	4	4	3	3	4	3	4	4	4	3	4
Entry Time	1	1	1	1	1	1	1	1	1	1	1	1	1
Entry Node	14	13	14	11	15	15	18	13	19	10	13	17	13
Capacity	4	1	1	20	12	13	5	24	3	7	10	5	15

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The notebook is a convenient interface to access and alter parameters of the microworld model. It is a control panel of many different aspects of the model that the user can adjust using a single screen. The designer decides what goes into the notebook, and its contents can be changed depending on user needs by going into the contents of the model and copying and pasting parameters into the notebook. The matrix shown above is one aspect of the notebook used to assign transportation resources and to establish connectivity between nodes. The top row of the notebook lists the transportation resources. Below the name of each resource is a color circle, which is used to represent that resource in the simulation. A distinct number matches each resource, as well.

Station A corresponds to the node where a given resource receives supplies. The number is the same as the number in parentheses next to the name of the node. The number that appears in the pickup A row indicates the type of supplies that the resource receives at station A. The model handles three distinct sorts of supplies. If the number is 0, supplies are not loaded. If the number is 1, one type of resource is loaded. The other resources are designated by the numbers 5 and 20. The number 99 causes any type of supply available to be loaded onto the resource.



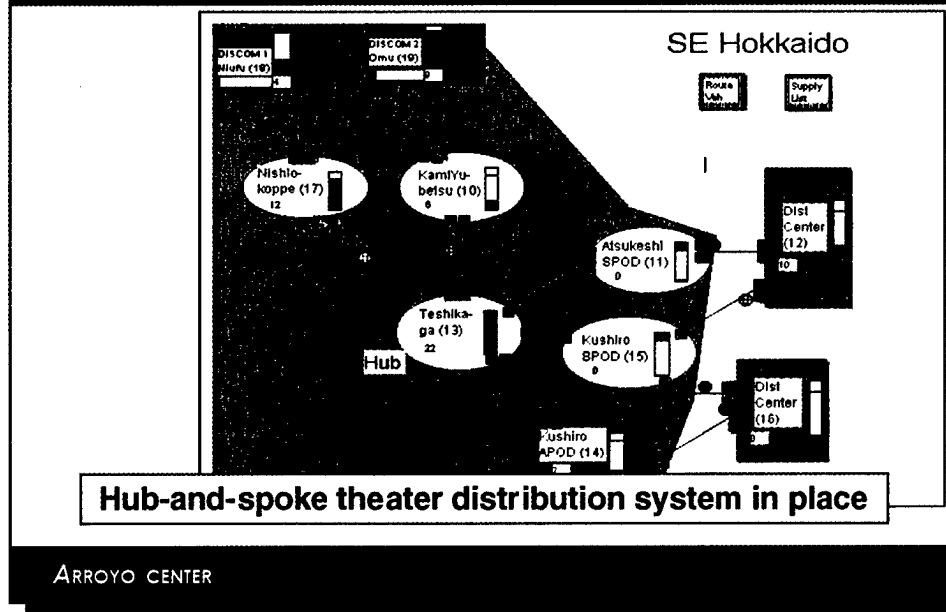
This prototype model allows the user to designate up to two intermediate drops. Station A is the point where supplies are received and station B is their destination. Two intermediate drops may be selected. The rows IDO1 and IDO2 allow the user to choose the nodes where intermediate drops occur. The rows #DO immediately below each IDO row allow the user to specify the quantity of supplies dropped off. If these four rows (IDO1, IDO2, #DO's) contain the number 0, intermediate drops do not occur. Station B designates the destination of the supplies originating from A. Pickup B indicates the supplies that the resource picks up from station B. The coding is the same as in pickup A.

The speed of the transportation resource determines the time necessary for a resource to travel from one node to another and scales with the actual speeds of the resources. Four speed levels exist in this version of the model. The prototype model operates on an aggregated time-step dimension. The distance between real points on the ground is represented in this model by delays along the arc between two nodes; the delays are scaled to both the transportation resource capability and the number of actual routes represented by the arc. We are trying to represent an aggregation of transportation assets into convoys, not individual vehicles. We also aggregate available main and alternate supply routes between supply activities (nodes). The model portrays how these convoys transit between supply activities with regard to the aggregate time step selected. For example, in one model, we simulated six hours as one time step; this allowed us to rapidly simulate thirty days of operation, taking only several minutes for each iteration. This rapid simulation time, with a real-time graphics display, helped illustrate system-level impacts of policies at each echelon.

The entry time allows the user to set when a resource begins operation during the simulation. This can also be used to make some resources inactive by choosing a time in excess of the run time for the simulation. The entry node is the node where the resource appears during the course of the simulation. Again, the node number is the number in parentheses next to the name of the node.

The capacity of the resource is set to be proportional to the known capacity of the resource whose name appears above. While the model operates, a transportation resource cannot leave a station from which it picks up supplies until it is fully loaded. Thus, large-capacity resources will require a longer time to fill.

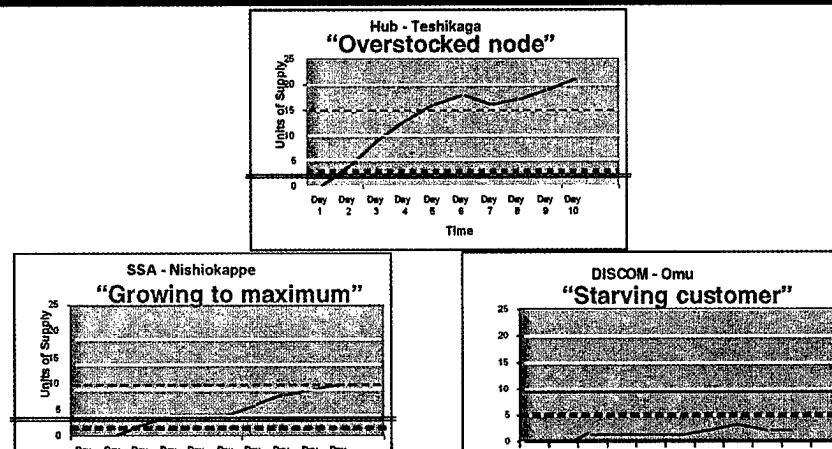
## “Design distribution network with adequate flow and robustness”



As mentioned above, the distribution network is fixed, but distribution policies are allowed to vary. The student can create a hub-and-spoke distribution system by causing supplies to collect from the distribution centers to the ports and from there to a hub. At the hub, the supplies are grouped and redistributed forward using the transportation resources selected by the student for that purpose. Thus, each node corresponds to a drop-off or transit point in the supply network, and the communications lines are aggregated distribution routes that could be networks of roads, air links, rail networks, or other paths appropriate to the transportation resources in use.

As the model operates, the student can monitor the success of this distribution policy by noting how well the nodes are supplied and whether any difficulties arise along the network. The student can also verify that transportation resources are sufficiently used and do not spend excessive time waiting to be loaded.

## “Monitor distribution network status and manage its flow”



**The hub appears to be a bottleneck: a DISCOM is  
starved while one SSA is getting too much**

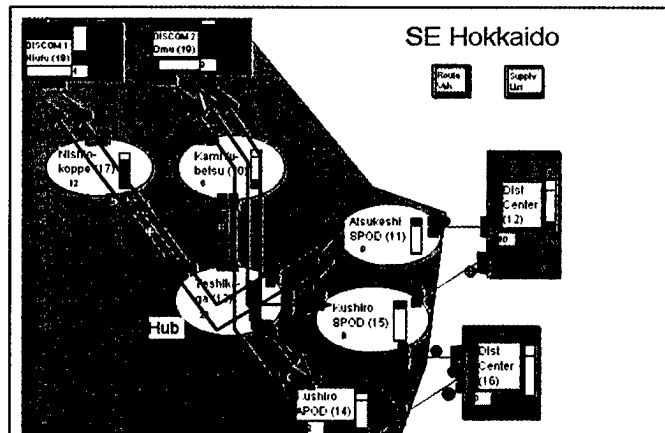
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In the model, information displayed at the nodes indicates the quantity of supplies present. A vertical bar at the node increases in proportion to this quantity and a red flag atop the bar lights up when supplies are beyond set limits. These could be low values (too few supplies) or high values (too many supplies), and these set-point values may vary from node to node. The nodes also consume supplies to reflect the consumption that occurs at intermediate points of a supply chain.

In one configuration, the model operates as a hub-and-spoke system in which transportation resources originating at supply ports converge on a hub at Teshikaga. Supplies accumulate there and evidence of this behavior is fed back to the student graphically, as shown above. Supplies cannot move forward from the hub at the same rate as they arrive. Meanwhile, the DISCOM at Omu gets too few supplies. At the same time, the SSA at Nishiokappe accumulates stocks of supplies.

At this point, the student can alter the system and rerun the simulation to see if performance is improved.

## “Take appropriate actions to work around choke points”



**To alleviate bottlenecks evident with the hub-and-spoke system, a direct delivery alternative is tried**

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As an alternative to the hub-and-spoke system, a set of policies to run direct delivery is attempted. In this formulation, there are no intermediate drop-off points to take supplies. Stocks flow from the ports to their ultimate destination. This modification is accomplished from the notebook. The student runs the model again and compares results with previous alternatives.

The direct delivery policy presents its own limitations, which become apparent by running the simulation. Using microworld simulations, the student can learn the tradeoffs between direct delivery and hub-and-spoke over a time horizon. As a result, policies combining aspects of direct and hub-and-spoke deliveries can be formulated to compensate for the deficiencies of either pure strategy. A microworld simulation provides a powerful tool to rapidly evaluate the consequences of these new policies over a particular time horizon.

This example, though informative and interesting, is hypothetical. During training sessions, students expressed a desire to see a microworld model based on a real-world case.

## **Microworld Models Can Also Address Phases in a Campaign**

- **Rather than hypothetical scenarios, use scenarios and data collected during actual operations**
  - need to address time element/phasing of operations when planning CSS support
  - use empirical data, specify class of supply
  - demonstrate flexibility, rapid development of microworld models for training
- **Example of Operation Joint Endeavor (OJE) fuel support to peacekeeping operations in Bosnia**

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As a real-world example, we chose the provisioning of fuel during Operation Joint Endeavor (OJE) to support the peacekeeping operation in Bosnia. This proved to be a fortunate choice, as the research into this case provided not only a good set of data from a recent operation but also an example of an operation that underwent several phases.

In the OJE example, we had available data on issues and receipts of fuel over a period covering the initial build-up to sustainment and then to mission hand-off. This model offers an example of the flexibility of microworlds for training. With these data, we constructed a model that addressed the time element or phasing of this operation, focusing on the planning for CSS support.

## Elements of Distribution Policies Interact During and Across Phases of an Operation

Phase	Customer Demands	Transportation Resources	Time	In-theater Stockage
<i>Build-up</i>	high	need many	critical	little or none
<i>Sustain</i>	moderate	need fewer	not as critical	mostly good
<i>Mission Hand-off</i>	high	need many	critical	temporary shortages

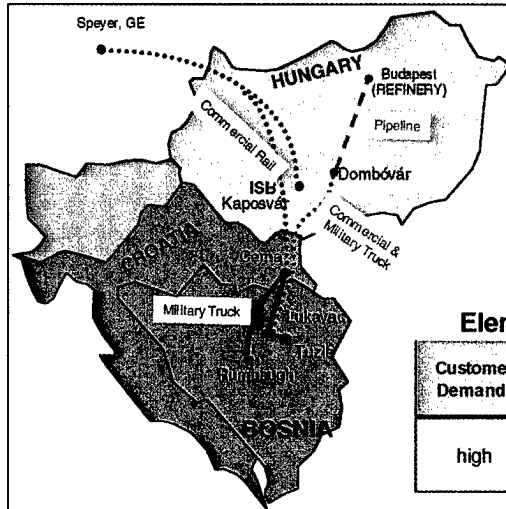
**Policies must address the inherent tradeoffs in the interactions of the elements above. (think in terms of risk across a row and across time between the rows)**

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As stated above, it is important for CSS staff planners to think across the phases of operation. In Operation Joint Endeavor, the mission underwent three distinct phases. As the staff planned for the distribution of fuel for the forces going into the theater, they had to address the factors atop each column within a particular phase; e.g., high demands for supplies and transportation could drive them to favor high-capacity, dependable delivery to theater to reduce risk to the operation across the row.

But thinking across the phases in the operation, planners need also to consider the interactions between the rows in this chart and what tradeoffs might be implicit; i.e., after the initial build-up, demands will drop off, and the high-capacity channel into the theater may no longer be needed (or cost-effective). Such considerations are apparent in the example OJE fuel prototype model that follows.

## Operation Joint Endeavor Fuel Prototype Model: Build-up Phase of the Operation



**Stage I**  
**D+0 to D+131**

### Elements of Distribution Policies

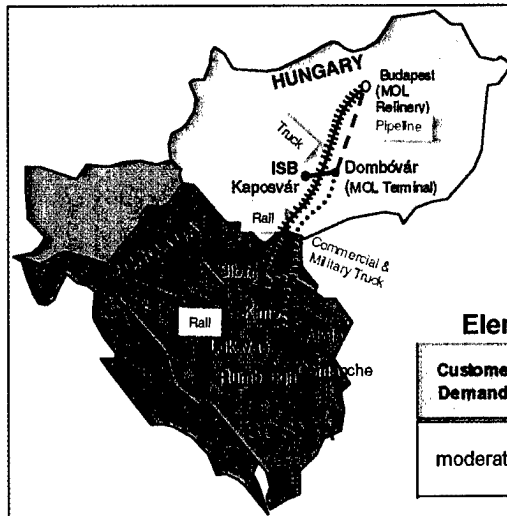
Customer Demands	Transportation Resources	Time	In-theater Stockage
high	need many	critical	little or none

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In the build-up phase of Operation Joint Endeavor (OJE), demands for fuel were high as the forces were moving there and little or no theater stocks were available [5]. Time was critical and there were heavy demands on the transportation system for movement of equipment and classes of supply besides fuel. Therefore, a dependable, high-capacity fuel delivery system into the theater was desired. This need was filled by the rail shipment from the established infrastructure in Germany and later by contract from a commercial fuel company in Hungary (MOL) [2, 3, 5].

The prototype model, depicted in this chart, reflects these rail connections to Croatia, with truck delivery into Bosnia proper [2, 3]. As created, the model can be altered relatively easily to reflect the change in demands as the mission and the theater mature.

## OJE Fuel Prototype Model: Sustain Phase of the Operation



### Stage II D+136 to D+xx

#### Elements of Distribution Policies

Customer Demands	Transportation Resources	Time	In-theater Stockage
moderate	need fewer	not as critical	mostly good

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In the sustainment phase, demands have moderated and time is less critical. There are theater stocks and transportation requirements are fewer [2, 3, 4, 5]. Thus, there is an opportunity to modify the fuel distribution system in the model to better meet these needs [2, 6].

The model reflects changes in demand between the build-up and sustain phases of the operation. The modification of the distribution network is relatively straightforward. Nodes are added or removed to represent the evolving operations. Links are established between them as appropriate. The properties of the transportation resources are then modified appropriately. Students can train on the new model to learn how the distribution needs of the system have changed over the time horizon of different phases.



## Lessons Learned in This Project

- **Different perspectives are important**
  - student
  - trainer
  - training developer
- **Iterative process**
- **Roles for CASCOM**

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This next section turns from the prototype models themselves to the lessons that have come from this work. These are grouped into two categories: lessons on the models and lessons on the role that CASCOM should play in this training development effort. We first discuss the desirable characteristics of the models.

The diagram illustrates the software architecture of the Arroyo Center, showing the flow of information and development between three main components: Student, Trainer, and Developer.

- Student Overview:** This section shows a map of the SE Hokkaido area with various locations marked. Below the map is a **Notebook** interface, which includes a list of stations (Station A, Pickup A, EOI, IDO, IDO, IDO, Station B, Pickup B, Space) and a grid for tracking entry times and capacity.
- Trainer Nodes & Arcs:** This section shows a network diagram with nodes and arcs, representing the flow of information between different parts of the system.
- Developer Objects and Functions:** This section shows a detailed network diagram with nodes and arcs, representing the objects and functions used in the development process.

Arrows indicate the flow of information and development from the Student Overview to the Trainer Nodes & Arcs, and from the Trainer Nodes & Arcs to the Developer Objects and Functions. A curved arrow also points from the Notebook to the Trainer Nodes & Arcs.

Each level is discussed further in the following pages.

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## Overview

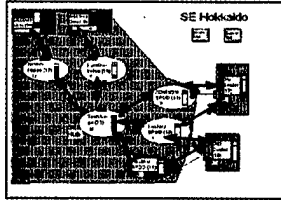


Figure 1 is a Gantt chart illustrating the schedule of a vehicle. The chart is organized into 12 columns representing time slots. The rows represent different activities or locations: Station A Pickup, IDO1, IDO2, IDO3, Station B Pickup, Speed, Entry Time, Entry Node, and Capacity. The vehicle's path is indicated by a black bar that starts at Station A Pickup at time slot 1, moves to IDO1 at time slot 2, then IDO2 at time slot 3, then IDO3 at time slot 4, then Station B Pickup at time slot 5, then Speed at time slot 6, then Entry Time at time slot 7, then Entry Node at time slot 8, and finally Capacity at time slot 9. The vehicle remains at Capacity from time slot 9 to time slot 12.

- **Overview of the theater distribution system; and**
- **Notebook of policy levers:**
  - **Stockage policy**
    - **Consumption rate (either from data or statistical distribution)**
    - **Initial supply levels**
  - **Network transportation policy**
    - **Assets to nodes**
    - **Convoy composition**
    - **Start dates**

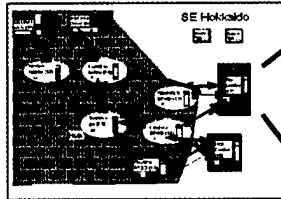
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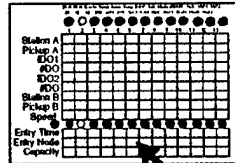
## Trainer Perspective

### Student

#### Overview

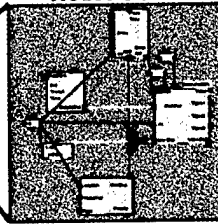


#### Notebook



### Trainer

#### Nodes & Arcs



All that students see plus:

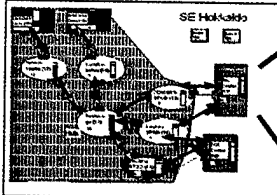
- Ability to build new nodes and transportation connectivity from a library; and
- Ability to add new assets
  - transportation
  - supplies

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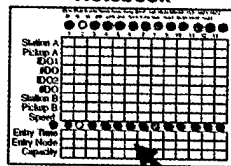
The trainer needs to be able to see all that the student sees and also to go one level "deeper" into the model. At this deeper level, the trainer needs the ability to build new nodes and transportation connections from built-in libraries or the ability to add new transportation or source-of-supply assets.

# Developer Perspective

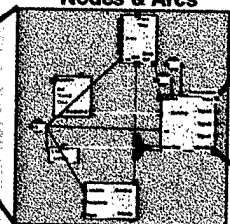
## Student Overview



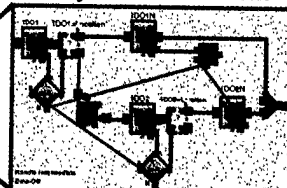
## Notebook



## Trainer Nodes & Arcs



## Developer Objects and Functions



- Ability to build new library items that represent technical and doctrinal processes

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Now the discussion will turn to the role for CASCOM in furthering this training methodology.

## Roles for CASCOM

- **Training developer**
- **Specific performance specifications**
  - **New libraries hotline**
    - traditional technical support, and
    - response within 24 hours for library modification
  - **New functionalities**
    - response within 30–45 days
    - new models
  - **Mentors to the field**

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CASCOM's primary role is in development of the training curriculum and tools, either internally or through contract. In either case, there are specific performance parameters that ought to be achieved. To take best advantage of many of the positive aspects of microworlds, support must be responsive and timely. For the development of new functions or completely new models, the training development office should provide a response within 30 to 45 days. For technical support and minor modifications to libraries, answers should be provided within 24 hours at the latest. Finally, CASCOM should provide mentors (senior, experienced logisticians) to the field to assist with this training and to the development of training materials.

The development of the microworld simulations presented in this document provides some indication of the time necessary for this process. After deciding how the Hokkaido distribution network would operate, the simulation was constructed from simple elements, most of which exist in the standard libraries. In a few instances, new functions were created by scripting the necessary code. Subsequent changes to the Hokkaido network required the rearrangement of elements in the now-functioning simulation. Initial development of the Hokkaido prototype model required two weeks. Rework, including optimization of the flow process and new configurations, occurred over a period of

several weeks. The OJE fuel prototype model shares many properties with the Hokkaido model. As a result, its implementation did not require the creation of new blocks. A prototype became operational in a few days. Over a period of two weeks, the model was characterized and its flow balanced to reflect the real-world data.

## **Items to Consider When Contracting for Microworld Simulations**

- **COTS technology (don't write code/reinvent wheel)**
- **Ability to read from**
  - a built-in data distribution (estimate), or
  - a table of numbers (empirical data),**with mathematical rigor**
- **Tool that can work at many levels: student, trainer, training developer**
- **Ready-built library of products that can represent both organization and resources**
- **GUI with reasonably good fidelity**

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This slide provides an initial list for items to consider when implementing the technology portion of this methodology. First is to purchase a commercial software product and avoid the burden of having a simulation project that attempts to both write code and write models. This commercial software should be able to read-in data from existing sources (such as spreadsheets) or to generate math functions from a built-in menu. Similarly, it should have an existing library of objects and functions, such as connectors, resources, and delays. It should be able to support the idea of different hierarchies or levels (student/trainer/developer). Finally, it should have a fairly good graphical user interface.



## **The Road Ahead: Redesigning MTP for Higher-Level CSS C2 Staffs**

- **Develop an initial skills matrix**
- **Select CSS staff skill sets to train**
- **Choose a COTS software package**
- **Practice using the existing RAND prototype models**
- **Continue to experiment with additional prototypes**

**Goal: Publish MTP on the World Wide Web with  
embedded microworld models available for download**

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The road ahead to redesign MTP for higher-level CSS command and control staffs, implementing a microworld-based training methodology, is straightforward. It starts with the development of a skills matrix for CSS staff training, then selection of sets of skills to train. With the help of an existing COTS simulation software package, the RAND prototype models can be practiced to gain some fluency with this method. Experimentation should continue with additional prototypes developed either by in-house staff or under contract.

The new MTP should not only outline the curriculum and the simulation enablers, it should be put on a Web site and provide a set of models that can be downloaded by units as needed for their particular training programs.

## REFERENCES

1. Bondanella, J.R., M.W. Lewis, P. Steinberg, G.Shin-K. Park, J.M. Sollinger, J.D. Winkler, J.M. Halliday, S. Way-Smith, *Microworld Simulations for Command and Control Training of Theater Logistics and Support Staffs: A Curriculum Strategy*, Santa Monica, CA: RAND, MR-929-A, 1999.
2. Field visit by John R. Bondanella, RAND Arroyo Center, with elements of the U.S. Army organizations supporting or participating in Operation Joint Endeavor: 21st Theater Army Area Command Headquarters in Germany and forward elements at the Intermediate Support Base, Taszar, Hungary, and with Task Force Eagle, Tuzla and Lukavac, Bosnia during May and June, 1996.
3. Walsh, Major, U.S. Army briefing, "240th Quartermaster Battalion and Sub-Area Petroleum Office Overview, Task Force Eagle Fuel Usage, JP8," 5 August 1996.
4. Telephone conversations between West Point Cadet Andrew Nelson and CPT Eric Brown, 55th Materiel Management Center, 310th Theater Support Command (Provisional), 15 June 1998.
5. Herson, Major James P., Jr., "Road Warriors in the Balkans," *Army Logistician*, PB 700-97-2, March-April 1997, Fort Lee, VA, downloaded from World Wide Web site <http://www.almc.army.mil/ORGNZATN/ALOG/MarApr97/ms113.htm>. Site accessed and working on February 19, 1999.
6. Hamilton, Major John S., "Task Force Eagle Fuel Managers Think Outside the Box in Bosnia," *Quartermaster Professional Bulletin*, Spring 1998, downloaded from World Wide Web site <http://www.lee.army.mil/quartermaster/bulletin/1998/tf-eagle.html>. Site accessed and working on February 19, 1999.